

National Aeronautics and
Space Administration



VIPER: PATHFINDING LUNAR RESOURCE UNDERSTANDING

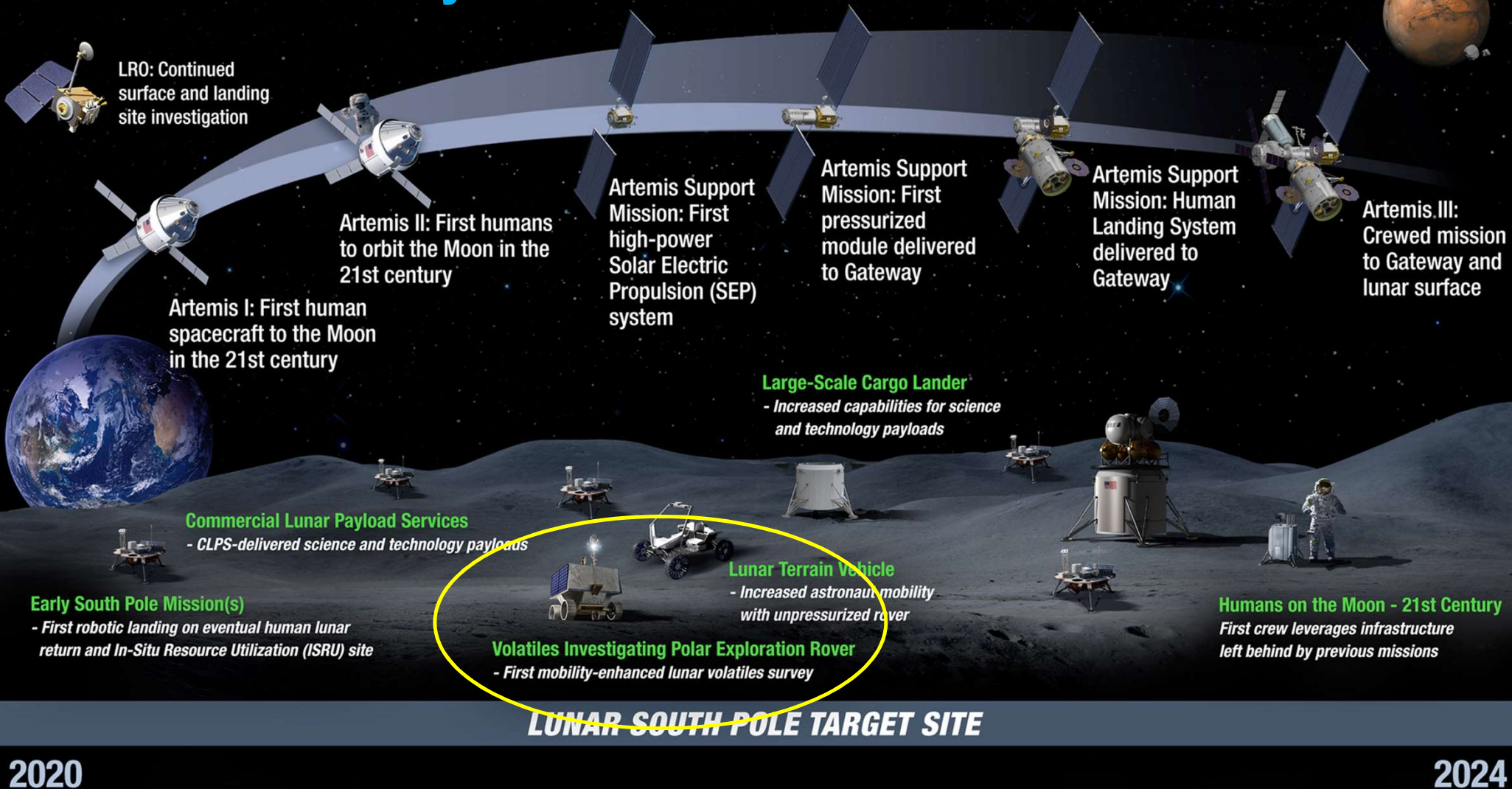
Volatiles Investigating Polar Exploration Rover

Daniel Andrews, PM

Exploration Science Forum

JULY 8-10, 2020

Humans Return by 2024

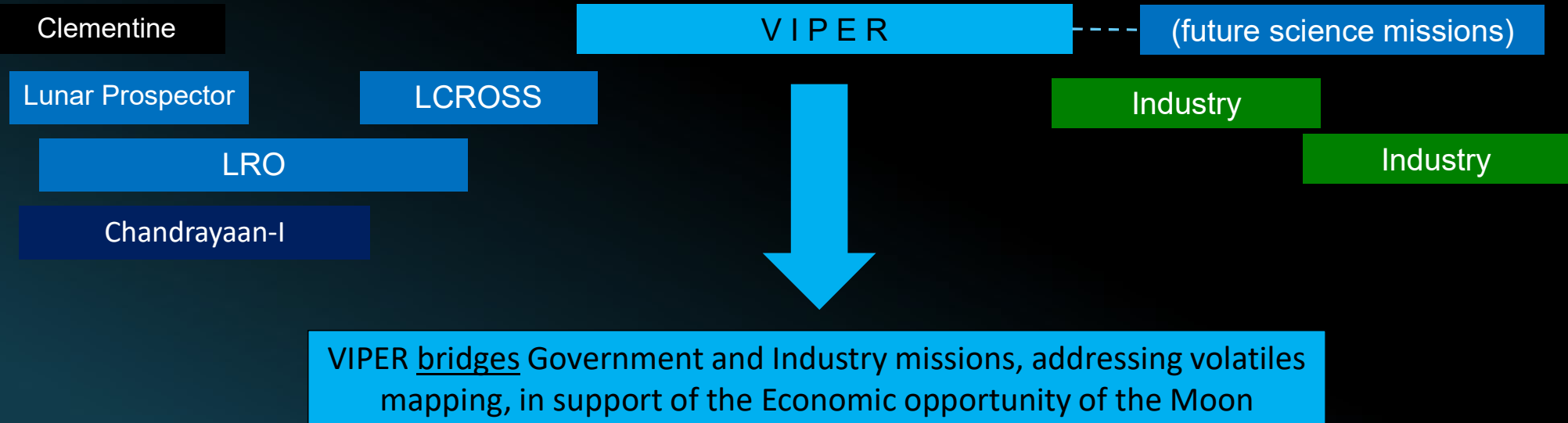


The Big Picture of Lunar Resources

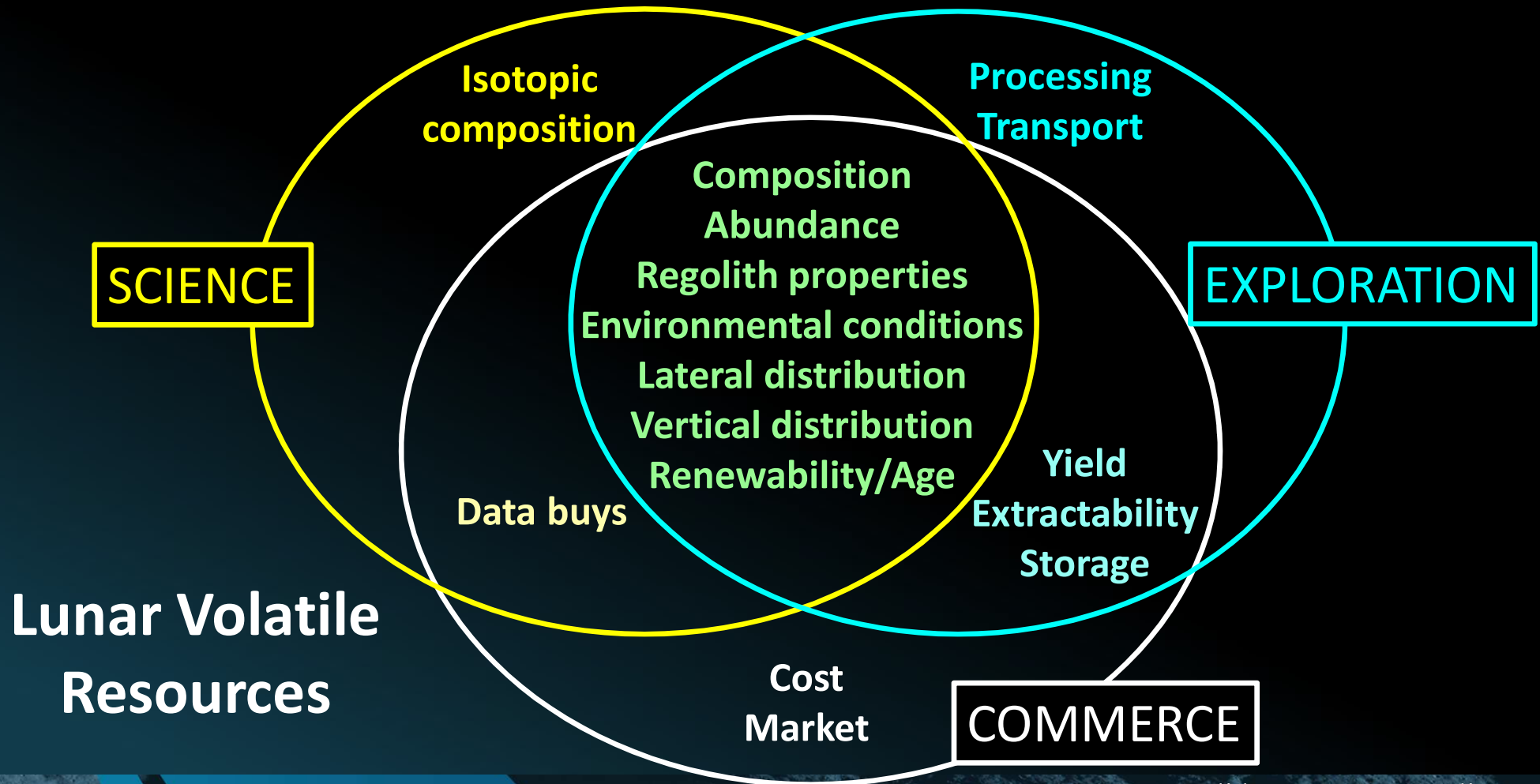
US Lunar Goals:



Missions:



Science enables Exploration enables Commerce





Why VIPER?

Direct measurement of polar volatiles

- *LCROSS ground-truthed the water* - VIPER will reveal the lateral / vertical distribution and physical state / composition of the volatiles
- *Q: Are some polar regions better than others (feasibility, economics, safety)?*

Enables research into In-Situ Lunar Resources

- VIPER will Build Lunar resource maps, steering the future commercial marketplace
- Understand ore grade availability of lunar volatiles for human sustainment and fuel



Where will VIPER explore?

VIPER will explore four “**Ice Stability Regions**” (ISRs)*:

- **Surface**: Ice expected stable at the surface - Permanently Shadowed Regions, (PSRs)
- **Shallow**: Ice expected stable within 50cm of surface
- **Deep**: Ice expected stable between 50-100 cm of the surface
- **Dry**: Ice *not* expected (top meter to be *too warm* to be stable)

**ISRs based on the predicted thermal stability of ice with depth*



VIPER Performance Specs

- **Mass:** ~430kg (948lbs) **Power (peak):** ~480W
- **Comms (DTE¹):** X-band
 - 230kbps (hi-gain) / 2kbps (omni)
 - 6-15[s] round-trip latency
 - Ground: DSN 34m dishes: Canberra, Goldstone, Madrid
- **Dimensions:** 1.5m x 1.5m x 2.5m (5ft x 5ft x 8ft)
- **Top Speed “Rails Driving”:** 20cm/s (0.5MPH)
- **Prospecting Speed:** 10cm/s (0.25MPH)
- **Distance Travelled (goal):** 20km (~12mi)
- **Waypoint Driving:** 4.5m (15ft) command distance
- **Camera Look-ahead:** 8m (26ft)
- **Obstacles / Slopes:** 20cm (8in) / 15deg
- **Expected Cold Environment:** ~40K (-390degF)

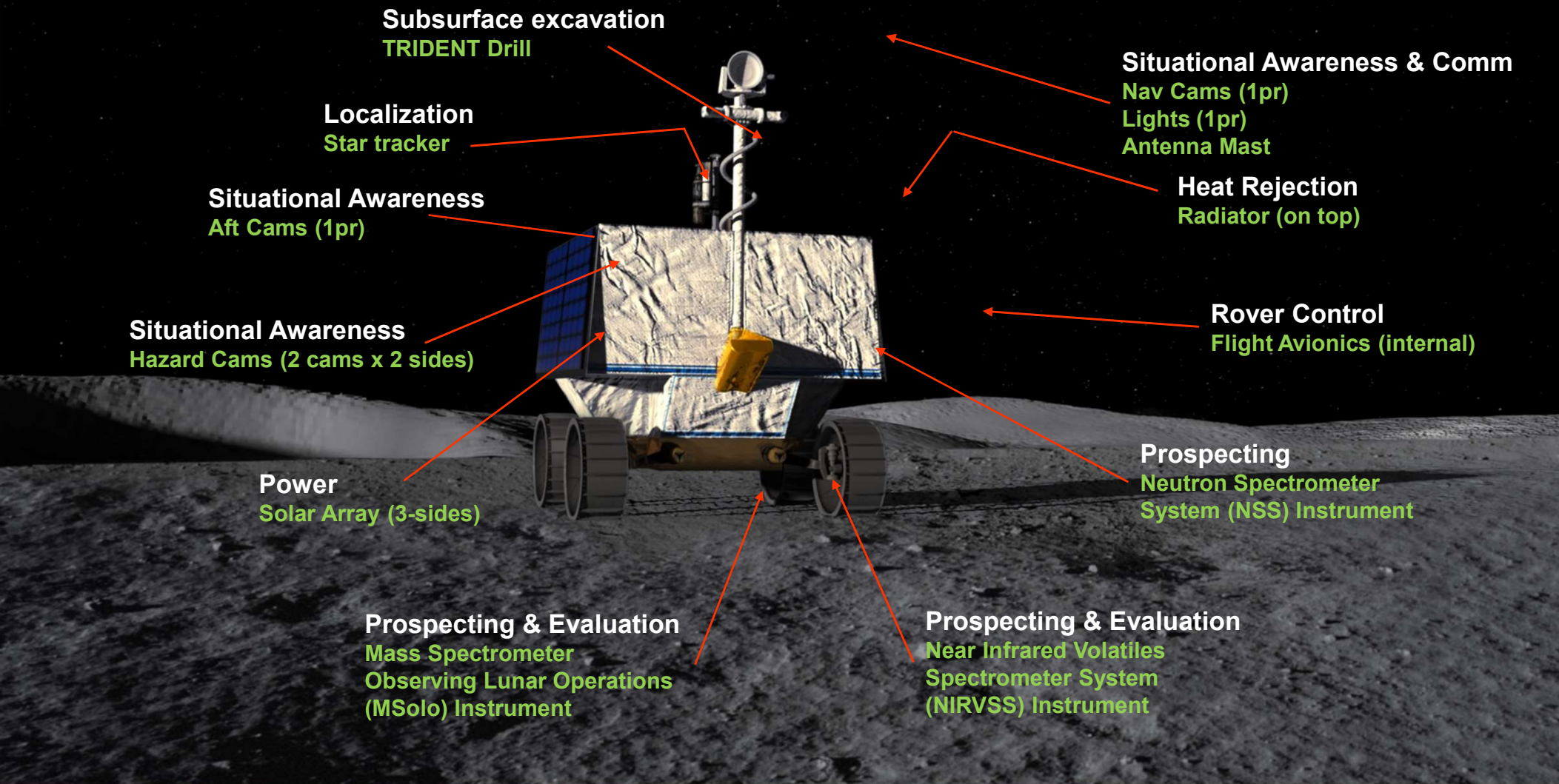
¹ DTE = Direct-To-Earth



VIPER Science Specs

- **Mission Duration:** 100+ earth days
- **Instruments:** Neutron, Near-IR, and Mass Specs; 1m Drill
- **Detectable H₂O Concentration:** 0.5% (by weight)
- **Drill Depth:** 1m (~3ft)
- **# of Surface Assays (drill sites):** 18
- **Dark Hibernation:** 40-80hrs (TBR) (VIPER driving case)
- **PSR Working Duration (w/drill):** 6hrs (RP driving case)
- **Surface Traverse Plan baselined:** @CDR (Q2/FY21)

VIPER Surface Segment (Rover + Instruments)





VIPER Science Manifest

The Regolith and Ice Drill for Exploring New Terrain (TRIDENT) HBR¹

- Excavates lunar regolith to a depth of 1-meter, in 10cm increments
- Measures forces, displacements and temperatures for regolith bulk properties
- Located under the center of the rover to minimize volatiles solar sublimation

Neutron Spectrometer System (NSS) NASA-ARC

- Prospects for hydrogen-rich materials while roving, mapping the distributions
- Located on the front of the rover to have an unobstructed view of the lunar surface

Near InfraRed Volatiles Spectrometer System (NIRVSS) NASA-ARC

- Prospects for surface water “frosts” and evaluates excavated materials
- Located under the rover studying water/volatiles abundance while roving & drilling

Mass Spectrometer observing lunar operations (MSolo) NASA-KSC

- Analyzes volatiles excavated while rover is traversing and drilling
- Located under the rover studying water/volatiles abundance while roving & drilling

¹ HBR = HoneyBee Robotics 10

Historical Planetary Rovers & VIPER

Driving on Other Worlds

Credit: historic spacecraft.com



Sojourner (1996):

- 0.6m x 0.5m x 0.3m
- 11kg
- Top Speed: 5cm/s
- Plutonium-238 RHUs



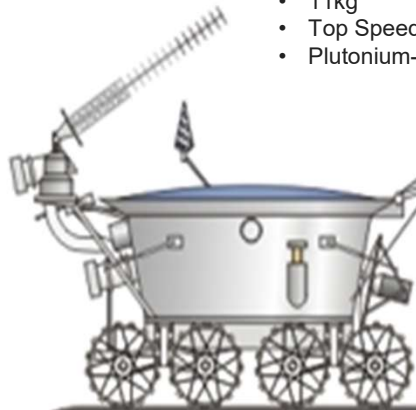
Mars Exploration Rover (2004):

- 1.6m x 2.3m x 1.5m
- 180kg*
- Top Speed: 5cm/s
- Plutonium-238 RHUs



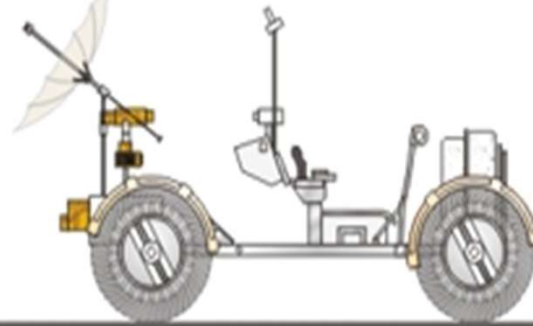
Mars Science Laboratory (2011):

- 3.0m x 2.8m x 2.1m
- 900kg
- Top Speed: 4cm/s
- Plutonium-238 MMRTG



Lunokhod 1 & 2 (1970 / 1973):

- 1.3M x 1.6m x 1.5m, 840kg
- Top Speed: 55cm/s
- Polonium-210 heat source



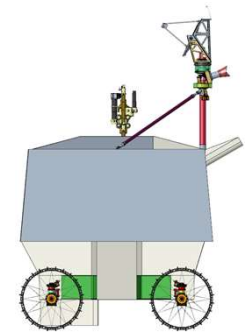
Lunar Roving Vehicle (1971 / 1972):

- 1.3M x 1.6m x 1.5m, 840kg
- Top Speed: 500cm/s



Yutu (2013 / 2019):

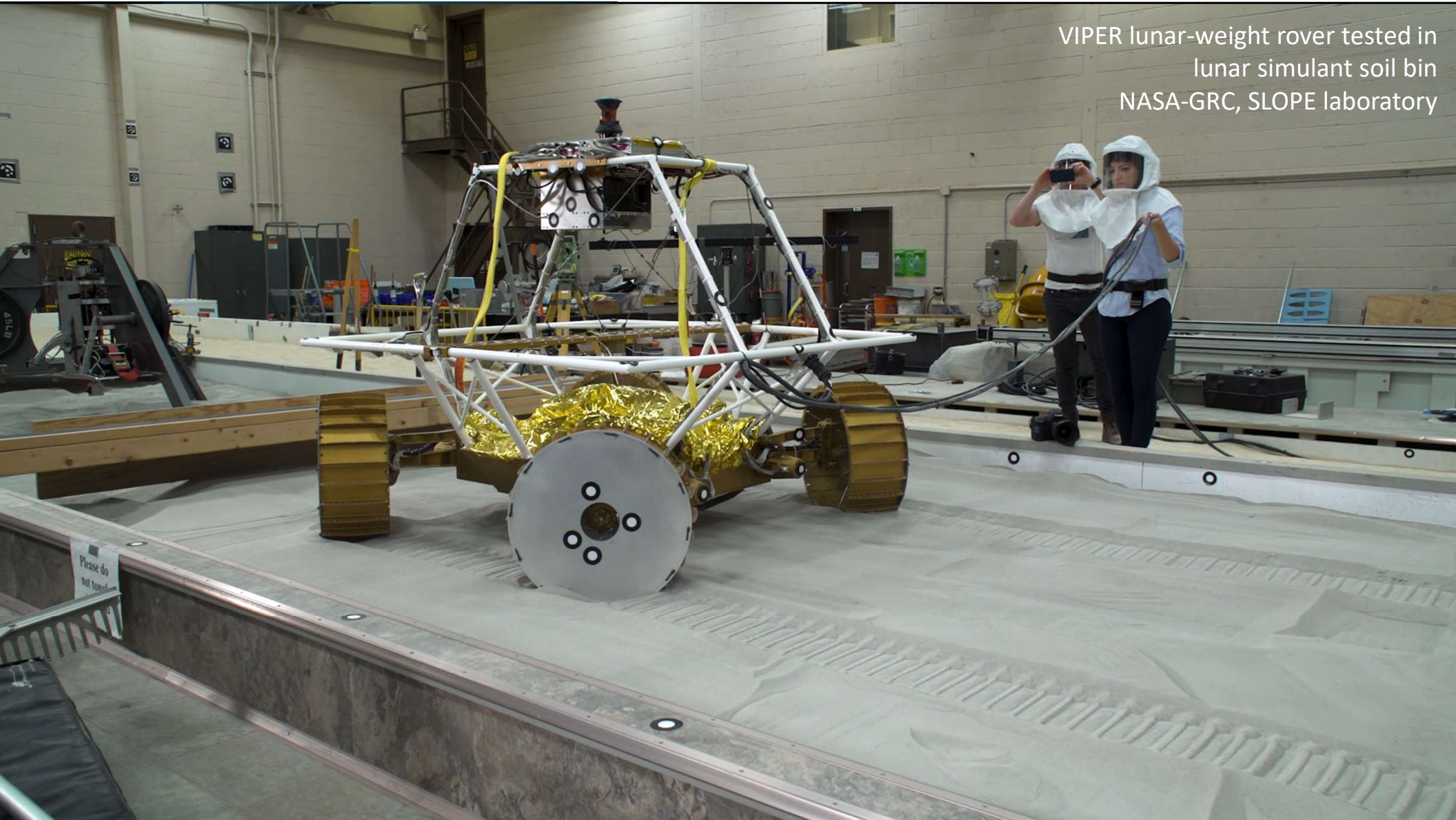
- 1.5m x 1.1m, 140kg
- 5cm/s
- Plutonium-238 RHUs



VIPER (2023):

- 1.5m x 1.5m x 2.0m, 430kg
- Top Speed: 20cm/s
- Electric heaters only

VIPER lunar-weight rover tested in
lunar simulant soil bin
NASA-GRC, SLOPE laboratory



The image features a dark, cratered lunar surface. A horizontal band of blue gradient, transitioning from a lighter blue on the left to a darker blue on the right, is centered across the image. The word "Questions?" is written in white, sans-serif font within this band.

Questions?



VIPER Lunar Challenges

- Demanding lighting environment
 - Sharp contrast and long shadows
- Rock/crater hazard distributions
 - Situational awareness is essential
 - Nav sensors, rover driver tools, ground software capabilities
- Uncertain polar lunar “trafficability”
 - Using best available data with significant science team inputs
 - Clever tools development (ex: SfS¹)
 - Drives rover complexity (ex: active suspension)
- Low elevation DTE communications
 - Multipath signal loss uncertainty drives power system & mass
- Highly variable polar temps
 - ~40K (-390F) in PSR, to 300K (80F) in sun

¹ SfS = Shape from Shadow